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A new species of *Nawawia* from Malaysia, with a synopsis of the genus

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Abstract — *Nawawia quadrisetulata* sp. nov., collected from submerged wood in Malaysia, is described and illustrated. It differs from other *Nawawia* species in having conidia with 4(–5) distal setulae. A synopsis of species in the genus is provided.

Key words — dematiaceous hyphomycete, lignicolous fungi, mitosporic fungi, saprotroph, taxonomy

Introduction

The anamorphic genus *Nawawia* was introduced by Marvanová (1980) based on *Clavatospora filiformis* Nawawi (Nawawi 1973), a hyphomycete found on submerged decaying twigs and petioles. The genus is characterized by having conidiophores that are dematiaceous, thick-walled, septate, percurrently proliferating, and bearing a terminal phialide with distinct collarette and producing unicellular hyaline conidia that are turbinate-tetrahedral to obpyramidal in shape, with their blunt corners at the distal end each provided with a distinct hair-like appendage. There are five reported species of *Nawawia* (Index Fungorum 2014): three from Malaysia (Crous et al. 2009, Kuthubutheen et al. 1992, Nawawi 1973), one from South Africa (Hyde et al. 1996), and one from Russia (Mel'nik & Hyde 2006). Hyde et al. (1996) described *N. dendroidea*, a synnematous species, and compared it with *Chalarodes* McKenzie and *Phialosporostilbe* Mercado & J. Mena. A sporodochial species occurring on leaves, *N. malaysiana*, was described by Crous et al. (2009).

During a survey of fungal diversity from submerged wood in Malaysia, we found an undescribed species of *Nawawia*, which is proposed here as

N. quadrisetulata sp. nov. Its holotype is conserved at the herbarium of the Centre for Biodiversity Research, Faculty of Science, Universiti Tunku Abdul Rahman (Perak campus), Kampar, Malaysia (UTAR). The ultrastructural features of the conidia were studied under the scanning electron microscope (FESEM, Model: JSM-6701F, JEOL, Japan). A synopsis of the six species in the genus is provided.

Taxonomy

Nawawia quadrisetulata Goh, W.Y. Lau & K.C. Teo, **sp. nov.** Figs 1–35

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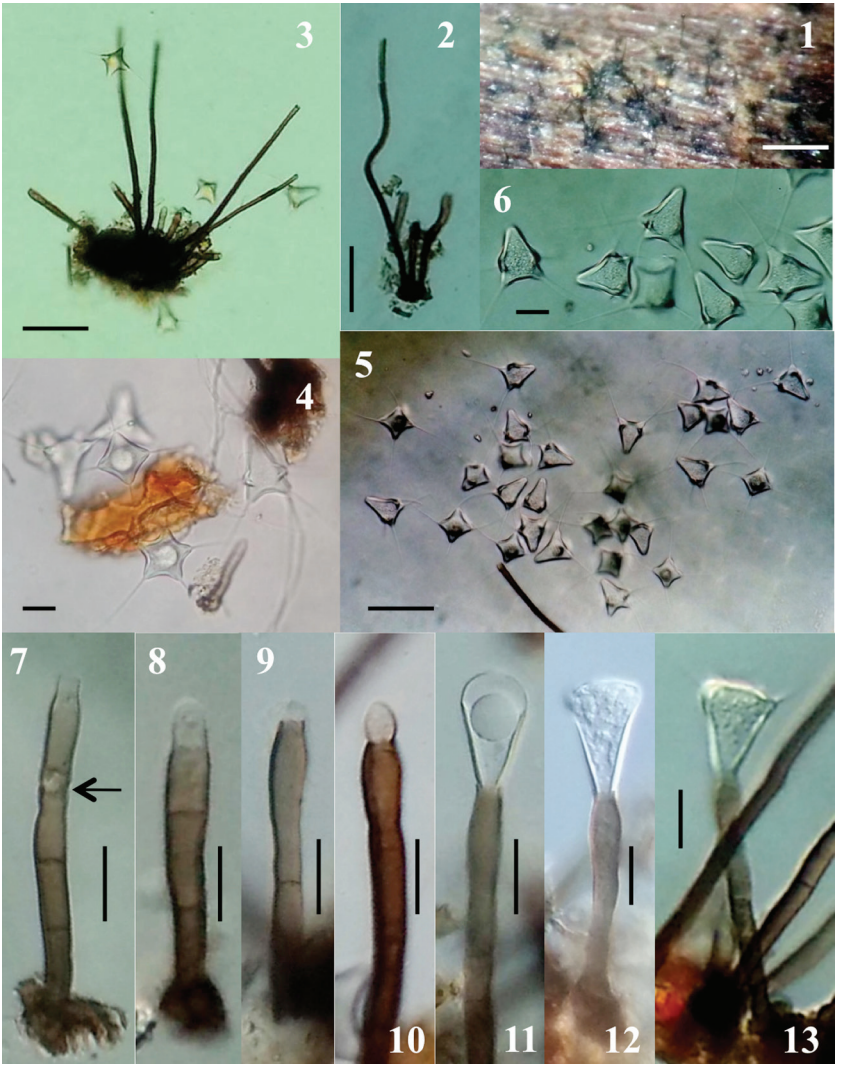
Differs from other species of *Nawawia* in having conidia with 4(–5) distal setulae but no basal setula.

Type: Malaysia. Perak, Menglembu, Bukit Kledang, on submerged wood, 10 November 2013, Wai-Yip Lau (**Holotype**, UTAR(M)-0004).

Etymology: *quadrisetulata*, refers to the conidium that usually bears four setulae.

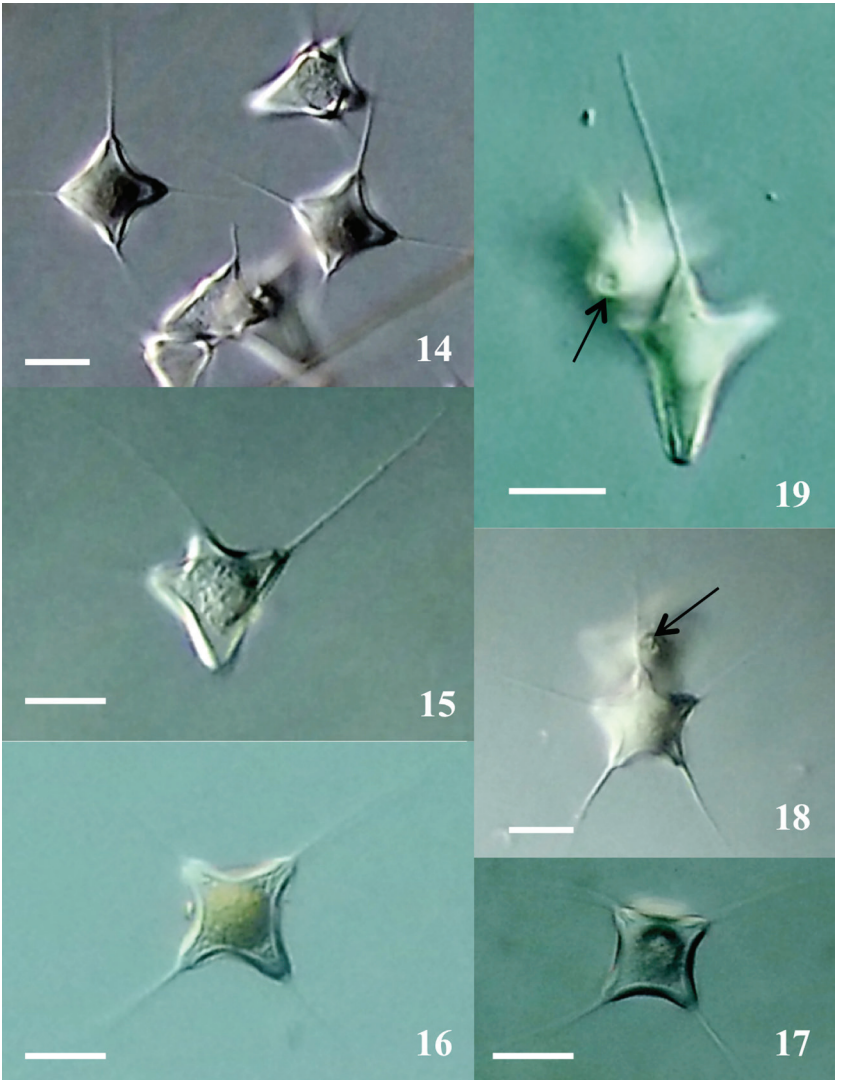
Colonies on the natural substratum effuse, hairy, dark brown, with glistening mass of conidia at the tip of conidiophores. Mycelium partly immersed and partly superficial, composed of pale brown, septate hyphae 2–3 µm wide. Stroma absent or meager (≤40 µm wide). Conidiophores cylindrical to slightly clavate, single or in small groups, erect, straight, unbranched, thick-walled, smooth, medium to dark brown, becoming paler towards the apex, often proliferating percurrently, 3–7 septate, 50–280 µm long, 5–8.5 µm wide. Conidiogenous cells integrated, terminal, phialidic, medium brown, smooth, cylindric-clavate 17–50 µm long, 6.5–10 µm wide at the widest part; collarettes proliferating without progression. Conidia hyaline, aseptate, smooth, thin-walled, 4(–5)-setulate, guttulate, obpyramidal, viewed from side turbinate-triangular, with 4(-5) blunt protruding edges at the broader distal end, viewed from above 4-lobed or cruciform with blunt protruding corners (bearing four setulae, one at each corner) and sometimes 5-lobed or stellate (bearing five setulae, one at each protruding corner), 30–37.5 µm long and 22.5–32.5 µm wide, base obconically truncate, with a depressed hilum 5–7.5 µm wide; setulae stiff, hyaline, 30–57.5 µm long, ca. 0.5 µm wide.

Comments— The conidia of this species bear 4–5 setulae at the distal end, and thus they are unique in shape. At least 100 conidia of this species were examined; the majority (93%) had 4 setulae and a few (7%) had 5 setulae. We have attempted unsuccessfully to grow this species in culture, using single-spore isolation method described by Goh (1999). Isolated conidia were inoculated to water agar, malt extract agar, cornmeal agar, and oatmeal agar, but none germinated.



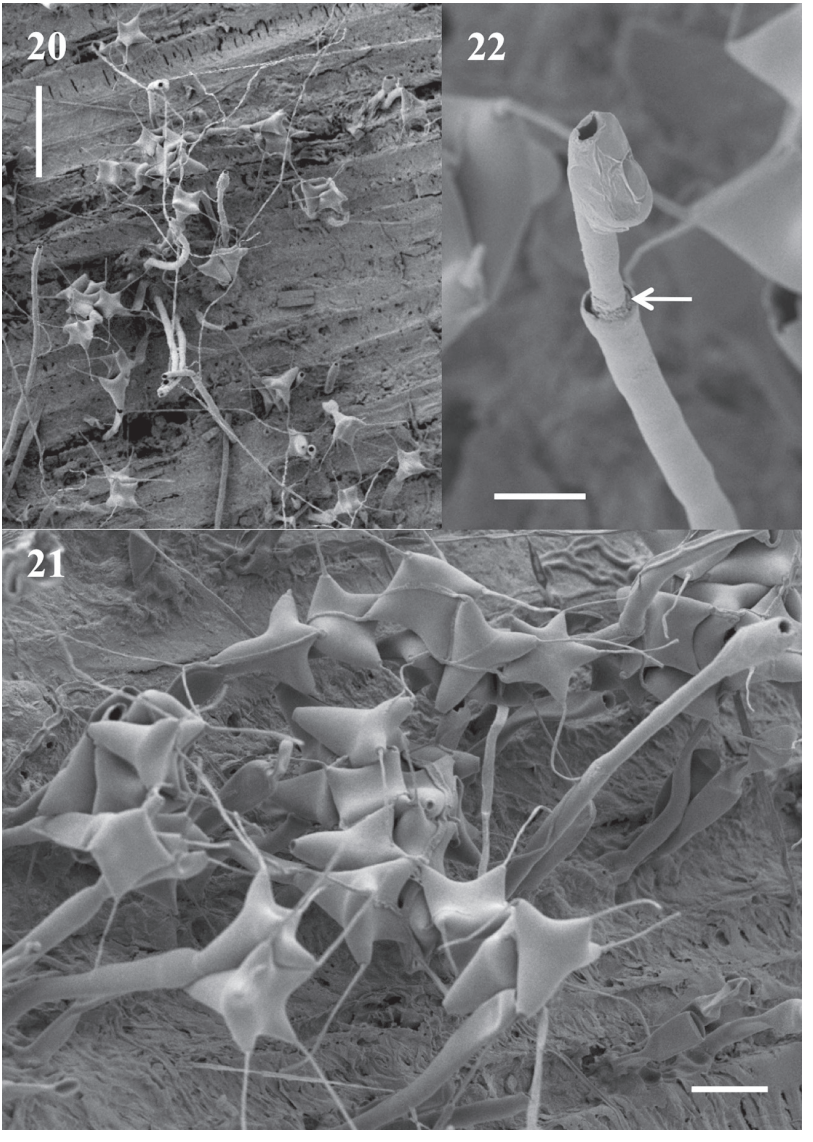
Figs 1–13. *Nawawia quadrisetulata* (holotype). 1. Colonies on natural substratum. 2, 3. Conidiophores. 4. Conidia under bright-field microscopy. 5, 6. Conidia under differential interference contrast (DIC) microscopy. 7. Conidiophore percurrent proliferation (arrowed). 8–13. Conidiogenous cell showing sequential development of conidia. Scale bars: 1 = 100 µm; 2, 3, 5 = 50 µm; 4, 6–13 = 20 µm.

A synopsis of the six species is presented in Table 1. Four of the previously described species (*Nawawia dendroidea* K.D. Hyde et al., *N. filiformis* (Nawawi)



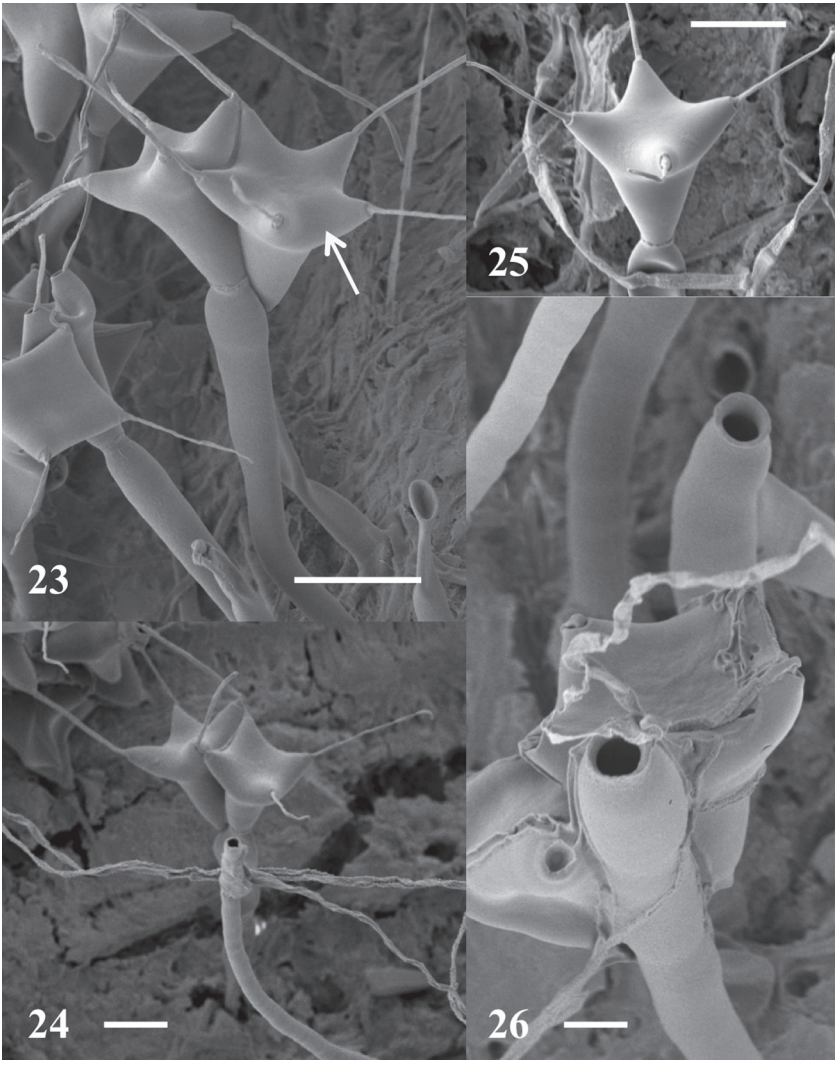
Figs 14–19. *Nawawia quadrisetulata* (holotype): conidia under DIC microscopy. 14. Quadrisetulate conidia. 15. Side-view of a conidium. 16. A conidium with a yellowish mass of oil in the cell. 17. A quadrisetulate conidium. 18. A conidium with 5 setulae; arrow points to the basal hilum of another conidium in the vicinity. 19. Conidia, with one conidium showing the basal hilum (arrowed). Scale bars = 20 µm.

Marvanová, *N. nitida* Kuthub. et al., and *N. sasae-kurilensis* Melnik & K.D. Hyde) have tetrahedral to obpyramidal conidia with 3 distal setulae (Hyde et



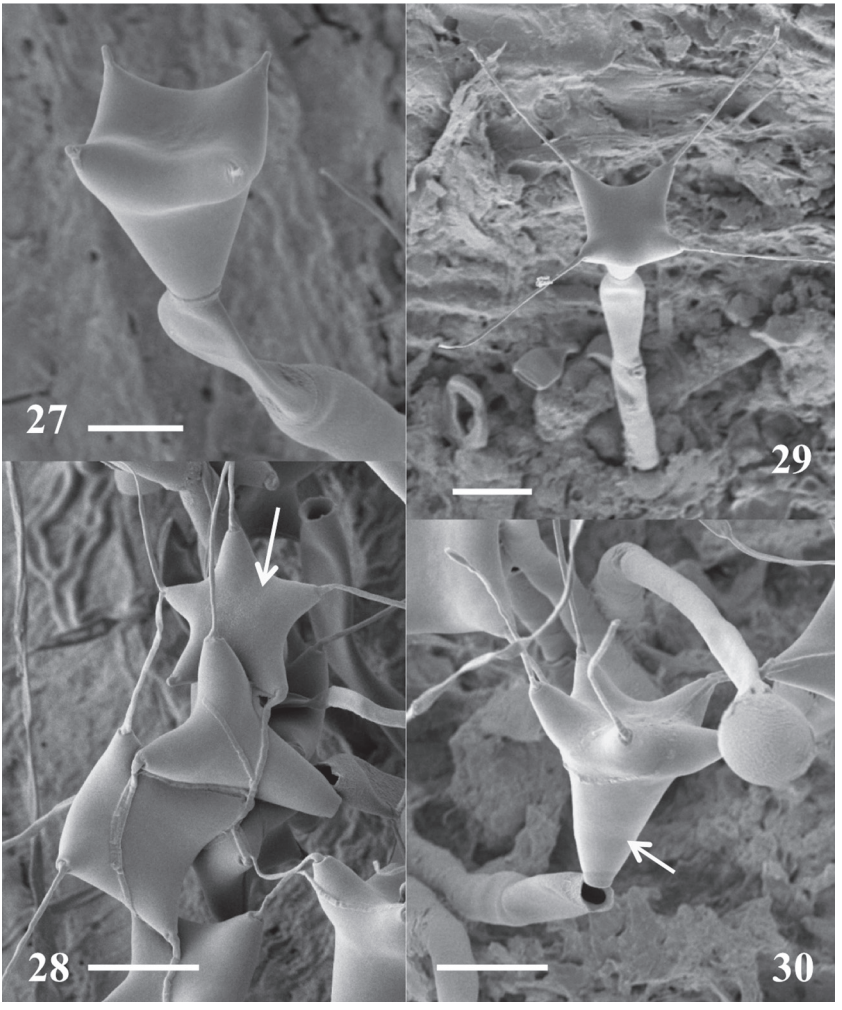
Figs 20–22. *Nawawia quadrisetulata* (holotype): SEM. 20. Colonies on surface of the natural substratum. 21. Conidiophores and conidia on natural substratum. 22. Phialide and percurrent proliferation (arrowed). Scale bars: 20 = 50 µm; 21, 22 = 20 µm.

al. 1996; Kuthubutheen et al. 1992; Marvanová 1980; Meľnik & Hyde 2006). Conidia of *N. malaysiana* Crous & S.S. Lee are 5-lobed and bear 4 distal setulae



Figs 23–26. *Nawawia quadrisetulata* (holotype): SEM. 23. Conidia produced from conidiophores. Arrow points to a conidium with 5 setulae. 24, 25. Quadrisetulate conidia produced at the apex of conidiophores. 26. Conidiophores showing the terminal phialides. Scale bars: 23–25 = 20 μm; 26 = 5 μm.

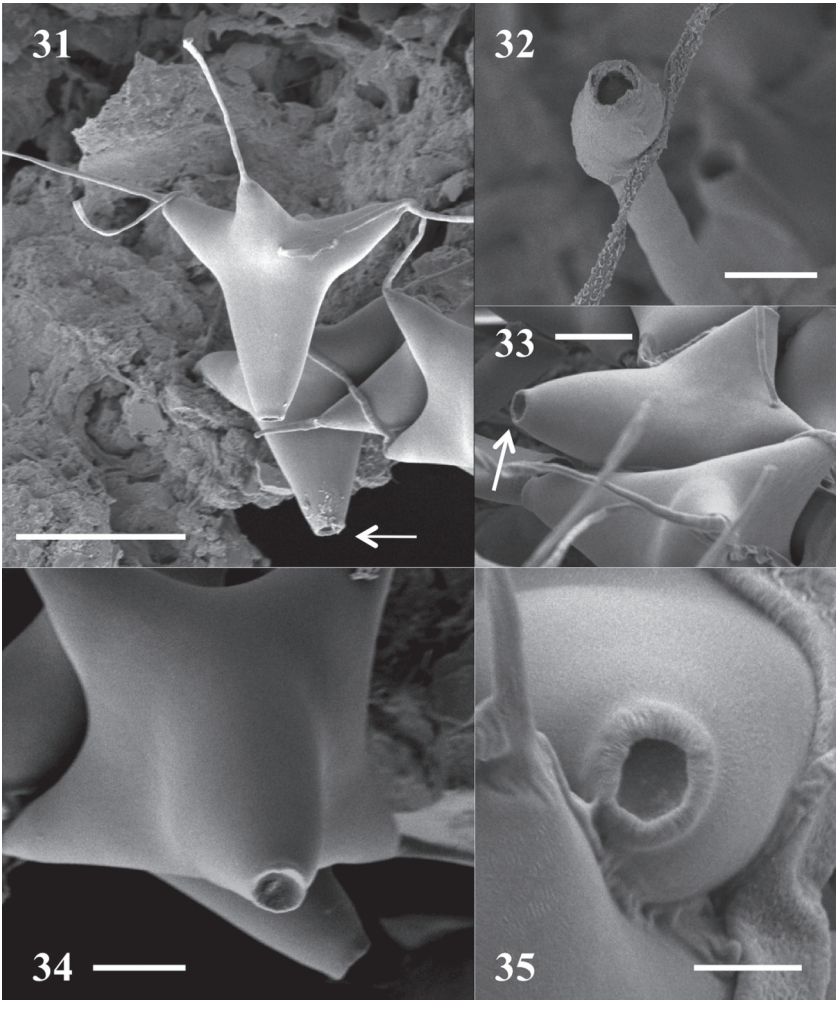
plus a basal setula (Crous et al. 2009), whereas *N. quadrisetulata* conidia lack a basal setula. Moreover, *N. malaysiana* differs from the other five species in being sporodochial, producing conidia that are distinctly smaller and fusoid to ellipsoid in side-view, and it was isolated from the apex of a conidiomatal



Figs 27–30. *Nawawia quadrisetulata* (holotype): SEM. 27. Conidium with the corners yet to form the setulae. 28. Conidia; arrow points to one that have 5 setulae. 29. Conidium attached to the apex of conidiophore. 30. A 5-setulate conidium (arrowed) at the opening of phialide. Scale bars = 5 μm.

spore mass of a foliicolous *Satchmopsis* species. Compared with the other five *Nawawia* species, *N. malaysiana* is atypical and its taxonomic placement in the genus is doubtful.

Under the scanning electron microscope (SEM), the conidial hilum of *N. quadrisetulata* is depressed and has a distinct rim, suggesting that the



Figs 31–35. *Nawawia quadrisetulata* (holotype): SEM. 31. Conidia; arrow points to position of hilum. 32. Phialide of conidiophore. 33, 34. Conidia showing the basal hilum (arrowed). 35. Conidial hilum. Scale bars: 31 = 20 µm; 32–34 = 10 µm; 35 = 5 µm.

conidial secession is rhexolytic, whereas the conidial hilum in *N. dendroidea* appeared to be flush with the obconically truncate base (Hyde et al. 1996), suggesting a schizolytic conidial secession. In the other four *Nawawia* spp., hilum morphology was neither reported in detail nor studied under the SEM.

Among the six *Nawawia* species, only *N. nitida* has conidiogenous cells that are doliiform and with distinctly flared collarettes similar to those found in

Table I. Synopsis of *Nawawia* species

Species	Conidiophores	Conidia	In vitro culture	Substratum	Original locality	Reference
N. dendroidea	Synnematous; 350–800 × 3–6 µm	Round-tetrahedral or obpyramidal; mostly with 3 apical setulae (4–8 µm long); 10–12 × 8–10 µm	Attempts unsuccessful	Submerged wood	Australia	Hyde et al. 1996
N. filiformis	Solitary; 70–315 × 4–8 µm	Turbinate to triangular; mostly with 3 apical setulae (15–34 µm long); 13–18 × 14–18 µm; with a *Chloridium* synanamorph in culture	Growth on MEA*	Submerged petioles and twigs	Malaysia	Nawawi 1973, Marvanová 1980
N. malaysiana	Sporodochial; 10–40 × 3–4 µm	5-lobed; with 4 apical & 1 basal setulae (3–9 µm long); 4–6 × 4–6 µm	Growth on MEA and OMA*	Associated with *Satchmopsis* sp, on *Eucalyptus* leaf	Malaysia	Crous et al. 2009
N. nitida	Solitary, short, bearing doliiform phialides; 25–75 × 10–12 µm	Round-tetrahedral or obpyramidal; with 3 apical setulae (38–74 µm long); 29–35 × 20–26 µm	Attempts unsuccessful	Submerged twigs	Malaysia	Kuthubutheen et al. 1992
N. quadrisetulata	Solitary or fasciculate; 50–280 × 5.5–10 µm	4–5-lobed; mostly with 4 apical setulae (30–57.5 µm long); 30–37.5 × 22.5–32.5 µm	Attempts unsuccessful	Submerged wood	Malaysia	This paper
N. sasae-kurilensis	Solitary, 160–240 × 5–10 µm	Round-tetrahedral; with 3 apical setulae (4–6 µm long); 10–14 × 8–11.5 µm	Not reported	Dead culm of *Sasa kurilensis* (Russian bamboo)	Russia	Mel'nik & Hyde 2006

* MEA = malt extract agar; OMA = oatmeal agar

species of *Obeliospora* Nawawi & Kuthub. (Nawawi & Kuthubutheen 1990). A *Chloridium* synanamorph (producing ellipsoid, non-setulate spores) was reported in cultures of *N. filiformis* (Nawawi 1973, Wu & McKenzie 2003), but synanamorphs are not known in the other five *Nawawia* species.

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